

#### Science Committee Members

Dave McComas, Southwest Research Institute, Chair

Carle Pieters, (Vice Chair), Brown University
Maura Hagan, NCAR, Chair of Heliophysics
Eugene Levy, Rice University, Chair of Planetary Protection
Janet Luhmann, UC Berkeley, Chair of Planetary Science
Brad Peterson, Ohio State, Chair of Astrophysics
Steve Running, University of Montana, Chair of Earth Science

Doug Duncan, University of Colorado
Noel Hinners, Independent Consultant
Mark Robinson, Arizona State University
Harlan Spence, University of New Hampshire (new member)

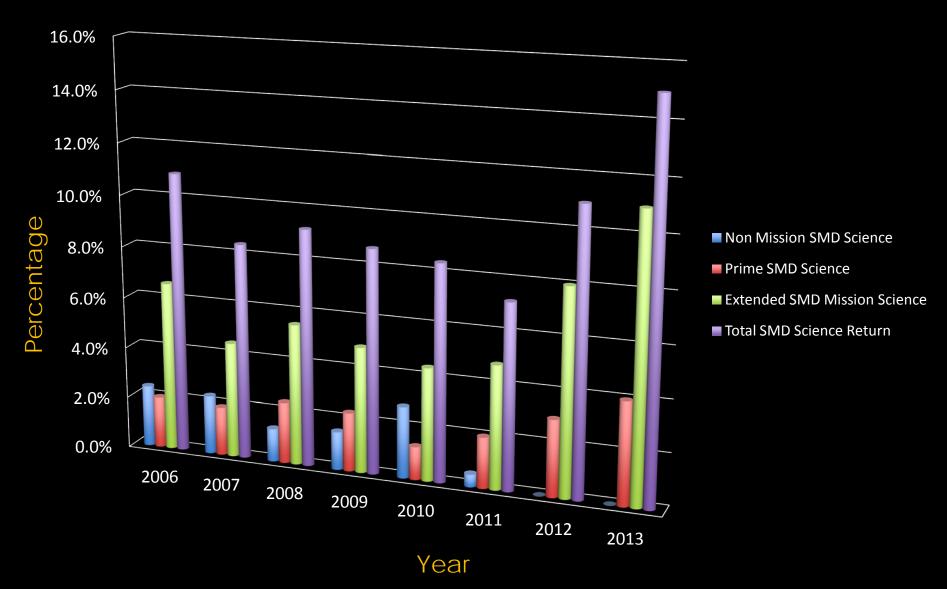
David Spergel, Chair of Space Studies Board (ex officio member)

### NATIONAL AERONAUTICS AND SPACE ACT OF 1958, Pub. L. No. 85-568, 72 Stat. 426-438 (Jul. 29, 1958) As Amended

Objectives of Aeronautical and Space Activities.The aeronautical and space activities of the
United States shall be conducted so as to
contribute materially to one or more of the
following objectives:

(1) The expansion of human knowledge of the Earth and of phenomena in the atmosphere and space.

#### SMD Science as a Percentage of Worldwide Science



#### Joint Session with HEO Committee

- Received presentation from SMD/Jim Green on Joint SMD-HEOMD activities
  - Focused on Planetary Science
  - The Committees asked for a broader presentation looking at SMD-HEOMD cooperation across all four science themes
  - The Committees asked to broaden the discussion to include cooperation with STMD
- HEO and SMD Joint Activities

  James L. Green

  Director, Planetary Science

  July 28, 2014
- Received presentation from HEOMD/Bill Hill & Stephen Creech on the Space Launch System (SLS)
  - The Committees asked about SLS launch cadence, sustainability, and costs to SMD missions
  - The Committees asked about development of pricing policy and plans for release of mission planners guide
- The Committees agreed that an extended joint session at the next meeting is needed
  - Planning to meet together in DC December 2-3, the week before the next Council meeting

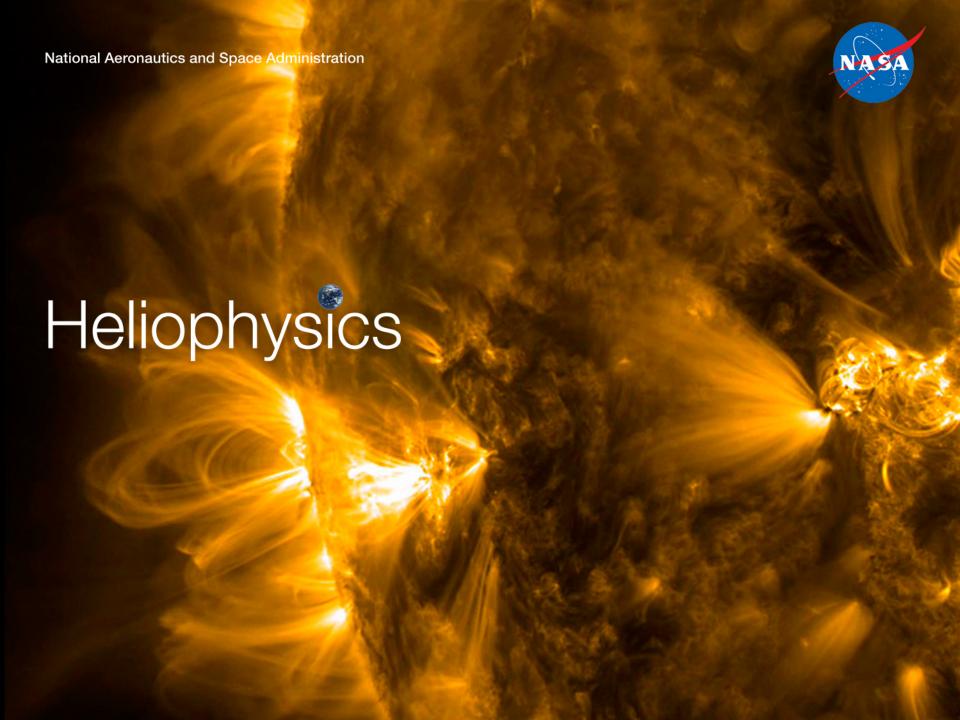


# Joint Session with Technology, Innovation & Engineering (TI&E) Committee

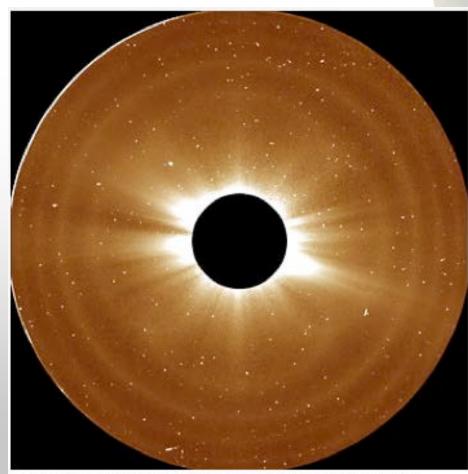
- Bill Ballhaus showed the prior draft recommendation concerning the current limited use of new technologies in small and medium science missions
- The Committees discussed how current practice/policy effectively discourages submission of small and medium science mission proposals with any technology development needed for missions success
- The Committees agreed on the text of a joint recommendation (to be referred to the AAs for SMD and STMD) for a study of existing practice and policy
  - Included at end of this presentation

## Outline

- Science Results
- Programmatic Status
- Findings



## NASA's STEREO Maps Much Larger Solar Atmosphere Than Previously Observed



Scientists used STEREO observations of the sun's atmosphere (the bright light of the sun is blocked by the black circle at the middle) on Aug. 5, 2007, to define the outer limits of the solar atmosphere. Credit: NASA STEREO.

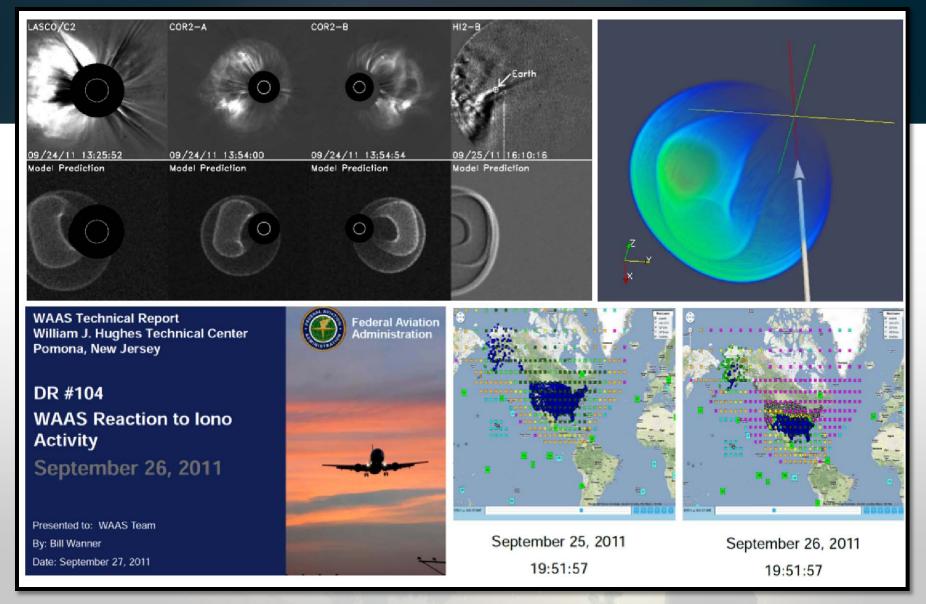
- Solar Terrestrial Relations Observatory (STEREO) observations observes the corona out to 5 million miles above the sun's surface (i.e., ~12 solar radii)
- Solar Probe Plus mission in development
  - o Travels within 9 solar radii of the sun
  - o 1st direct access to solar atmosphere
  - Unprecedented insight into coronal heating and Energetic Particles (EPs)
  - Revolutionize knowledge of origin and evolution of the solar wind and EPs

#### NASA's BARREL Returns Successful from Antarctica

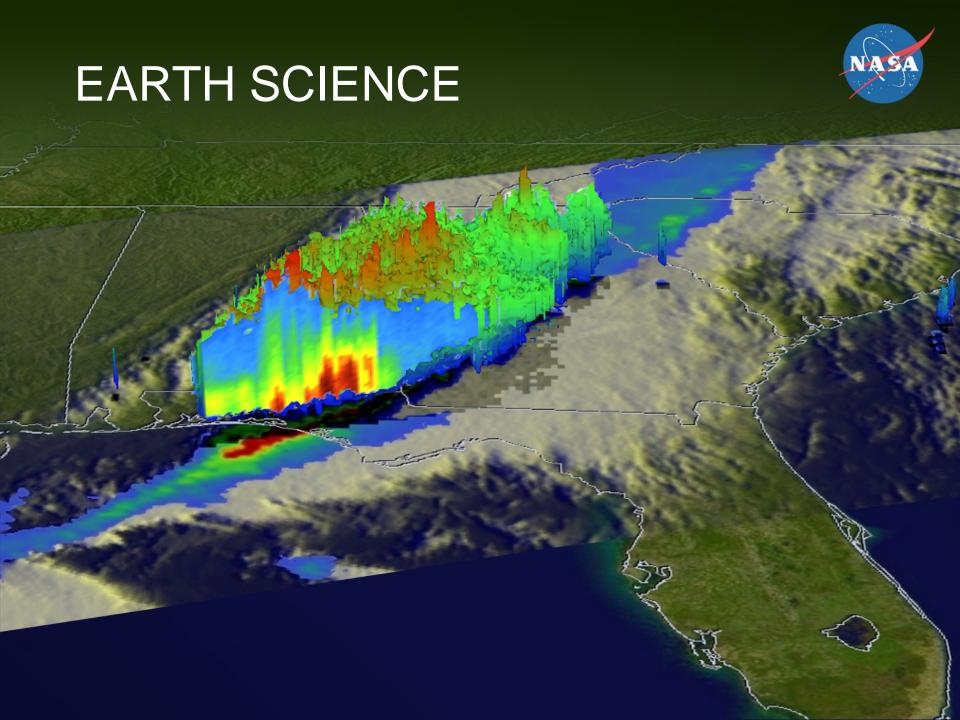




- Balloon Array for Radiation belt Relativistic Electron Losses (BARREL) mission returned from Antarctica – March 2014
  - o 20 balloons
  - 3 months duration
  - o 2nd year of campaign
- Measure precipitation of relativistic electrons from Earth's radiation belts
- Exploration of large bursts of precipitation at dusk
- Investigate correlations with Van Allen Probes radiation belt measurements
- Aim to understand how particles get ejected from belts
- Interagency and international support -NASA, NSF, NERC (UK), SANSA (South Africa)



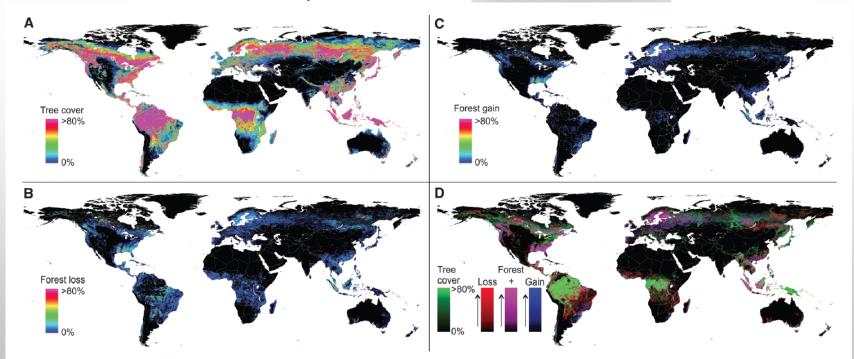
Ionospheric disturbances attributable to coronal mass ejections observed by STEREO and SOHO in September 2011 (upper left) resulted in significant degradations to the Wide Area Augmentation System (WAAS) navigation system (lower right), used to assist in GPS-based instrument landings at airports throughout the US.



# High-Resolution Global Maps of 21<sup>st</sup>-Century Forest Cover Change

NASA-funded researchers have produced the *first* high-resolution (30m) global map of forest cover change for 2000 – 2012 using data from Landsat.

Previous efforts were either sample based or had coarser resolution



**Fig. 1. (A) Tree cover, (B) forest loss, and (C) forest gain.** A color composite of tree cover in green, forest loss in red, forest gain in blue, and forest loss and gain in magenta is shown in **(D)**, with loss and gain en-

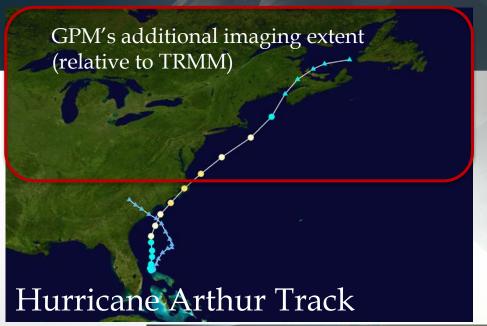
- 2.3 million km<sup>2</sup> of forest were lost
- 0.8 million km<sup>2</sup> of forest were gained

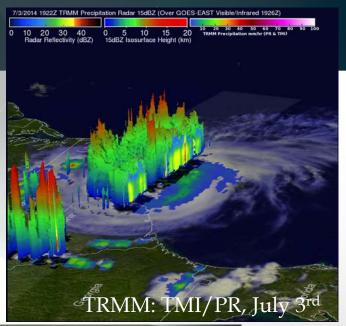
hanced for improved visualization. All map layers have been resampled for display purposes from the 30-m observation scale to a 0.05° geographic grid.

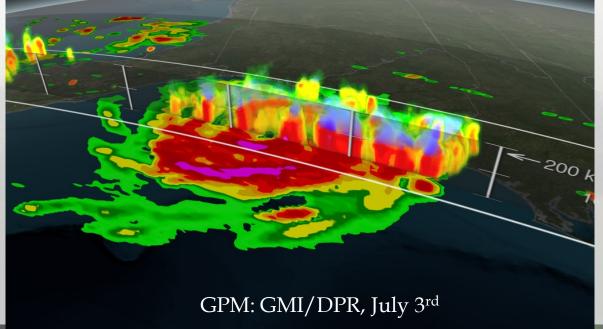
 0.2 million km<sup>2</sup> land experienced loss and subsequent gain

Hansen, MC, Potapov, PV, Moore, R, Hancher, M, Turubanova, SA, Tyukavina, A, ... Townshend, JRG. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, *342*(6160), 850–853. doi:10.1126/science.1244693

## Hurricane Arthur – July 1-7th, 2014

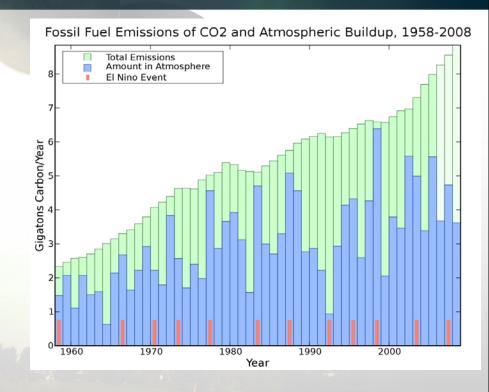






## The Mystery of the Missing CO<sub>2</sub>

- Humans have added >200 Gt C to the atmosphere since 1958
- Less than half of this CO<sub>2</sub> is staying in the atmosphere
- Where are the sinks that are absorbing over half of the CO<sub>2</sub>?
  - Land or ocean?
  - Eurasia/North America?
- Why does the CO<sub>2</sub> buildup vary from year to year with nearly uniform emission rates?
- How will these CO<sub>2</sub> sinks respond to climate change?



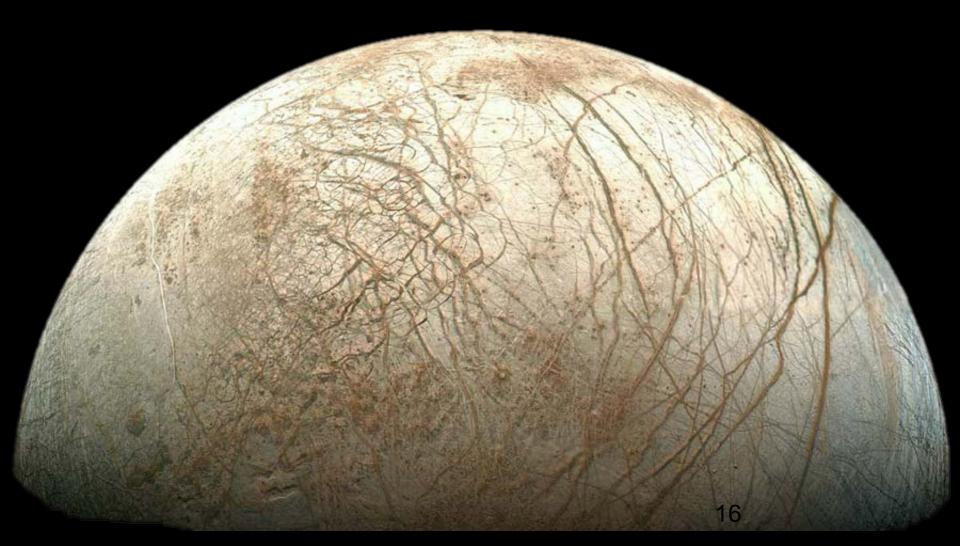


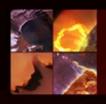






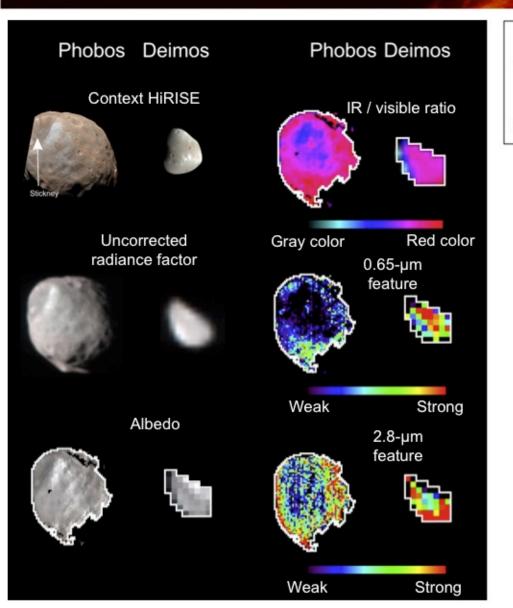
## Planetary Science





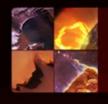
#### Bound Hydroxide Confirmed on Phobos & Deimos

Fraeman, A. et al. (2013) Icarus.



New spectral features on Mars' moons Phobos and Deimos record the first direct detection of bound hydroxide on the Martian moons, which may provide a potential *in situ* resource for water or hydrogen.

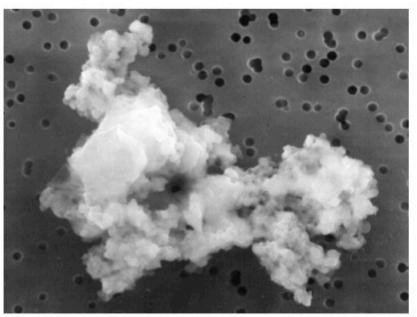
- One feature, centered at 0.65 µm, was measured on the entire surface of Deimos and for the red unit of Phobos, and may indicate OHbearing clay.
- The second feature, near 2.8 µm, is measured in all areas of both moons (though it too is stronger in the redder areas) and may indicate metal-OH bonds.
- There are two potential hypotheses to explain these features, although a combination of both may be possible:
  - Highly desiccated Fe-clay minerals present in the moons
  - A combination of Rayleigh scattering and absorption of small iron particles formed by space weathering processing, in combination with implantation of H from solar wind.
- The correspondence of evidence for water and clay, plus the moons' low albedo, suggests a composition for these moons similar to primitive carbonaceous meteorites.



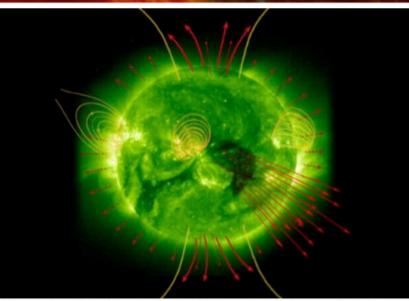
#### Elements for Life are Universal

### A new study shows that stardust floating through the Solar System contain tiny pockets of water.

Water in these particles are formed when the interstellar dust reacts with charged particles ejected from the Sun in the solar wind. Previously, the chemical reaction responsible had been simulated in laboratories – but new measurements show that water has been found trapped inside actual interstellar dust. Earlier measurements have also identified organic compounds in stardust, which suggest that these particles could contain the basic ingredients necessary for life.



Interplanetary Dust Particle. Image Credit: NASA, Stardust mission

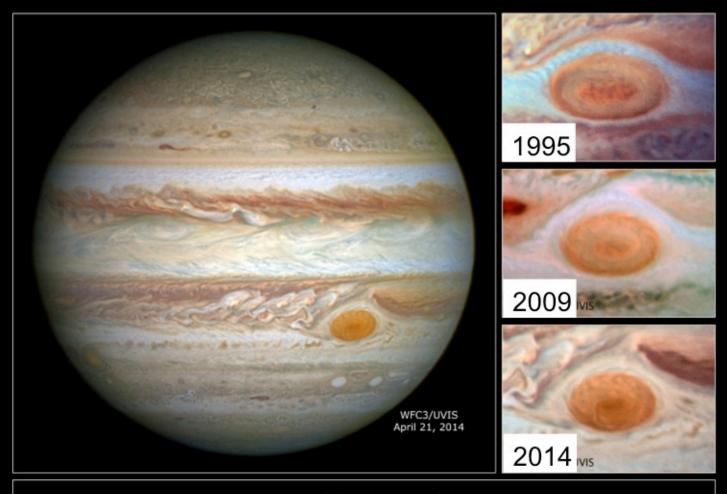


Charged particles in solar wind might produce water on stardust. Image Credit: September 18, 2003 image from the SOHO Extreme ultraviolet Imaging Telescope.

The interstellar dust containing these compounds would likely continually rain down on solar system bodies – acting essentially like tiny packages with everything needed for the origin of life. Since interstellar dust exists everywhere, and the water-forming reaction would happen around any star, particles with these characteristics would also fall on any extrasolar planet orbiting a star – increasing the chances that life is Universal.

Bradley et al. (2014) PNAS

#### Jupiter's Shrinking Great Red Spot



- Jupiter's Red Spot is a gigantic Earth-sized cyclone.
- Astronomers have observed the Great Red Spot shrinking for decades.
- It is now at the smallest size ever measured, 16,500 km (10,250 miles) across, shrinking at an unprecedented rate of 930 km (580 miles) per year. Its spin rate is speeding as it shrinks, like an ice skater bringing her arms closer to her body to spin faster.
- Scientists are studying this feature to learn what mechanisms could maintain such a large storm for extended periods.

Jupiter and the Great Red Spot Hubble Space Telescope WFC3/UVIS WFPC2

NASA and ESA STScI-PRC14-24a

# Radar Imagery of Near-Earth Asteroid (NEA) 2014 HQ<sub>124</sub>

Bistatic Radar observations at the closest approach!

2014 HQ<sub>124</sub> rotates approximately once every 20 hours. Lightcurve data from NEOWISE (right) shows the NEA is elongated (with a 0.8 magnitude change in amplitude as the object rotates) and the measured rotation period agrees with the radar data.

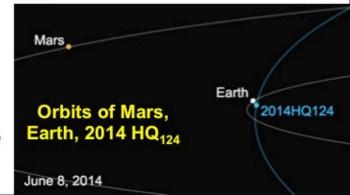
NEOWISE discovery tracklet of 2014 HQ<sub>124</sub>. (23-24 April 2014)

13.4 13.6 13.8 14.0 14.2 1.0 1.5 MID (days) 2.0 +5.677e4

Follow up observations and orbit determination showed 2014 HQ<sub>124</sub> would pass within 3.3 lunar distances (~1.3 million km) of the Earth. Its orbit is shown in blue (right), traveling from the south to the north.

The Goldstone and Arecibo telescopes obtained bistatic radar images, of 2014 HQ<sub>124</sub> on 8 June 2014, the day of its closest approach to Earth. Working together, with Goldstone emitting and Arecibo receiving, they produced spectacular imagery of this primitive body (left).

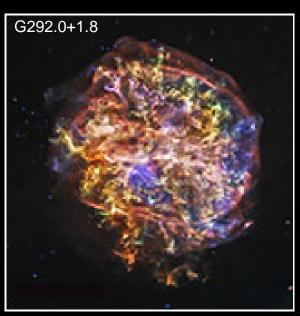
Radar measurements indicate this NEA is ~370 meters along its long axis and appears to be a contact binary, where two objects migrate together until they form a single body. Additionally, large boulders appear to be imbedded into the main body.

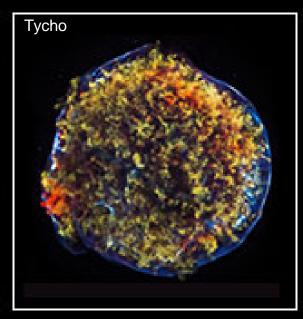




### Chandra Supernova Remnants - 15th Anniversary Images



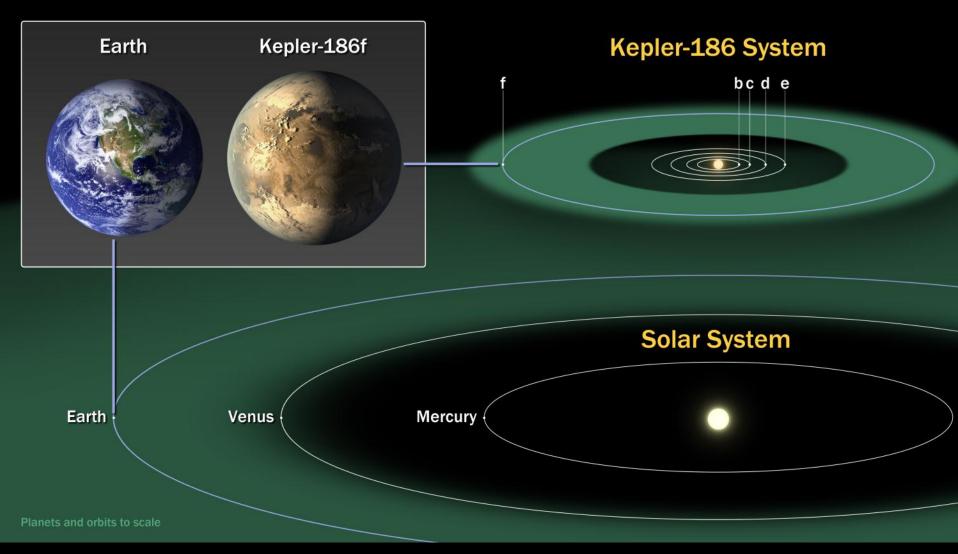




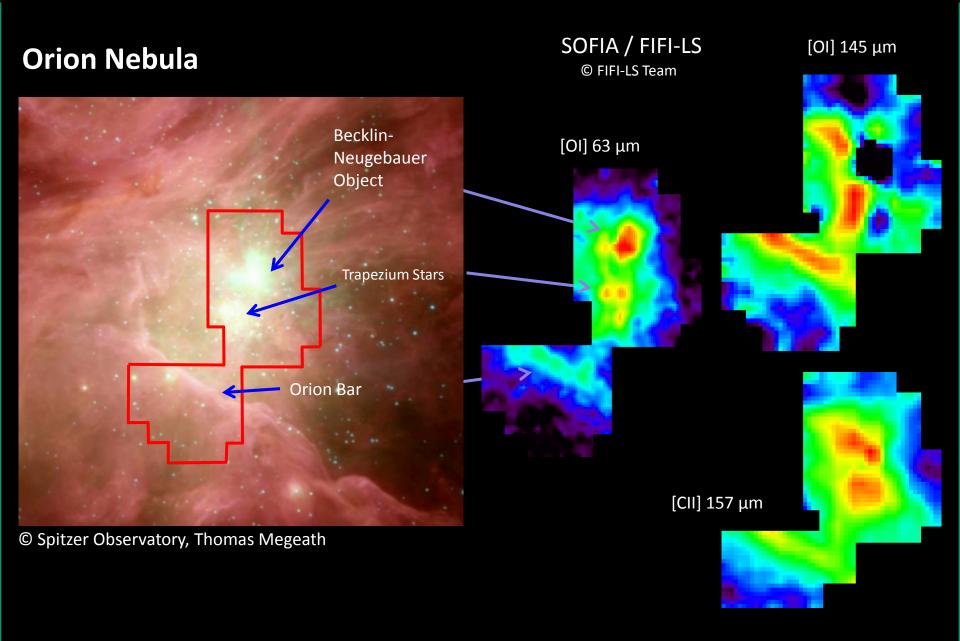


Credit: NASA/CXC/SAO

## Kepler 186f: First Earth-Size Planet in 'Habitable Zone'



#### **Stratospheric Observatory for Infrared Astronomy**

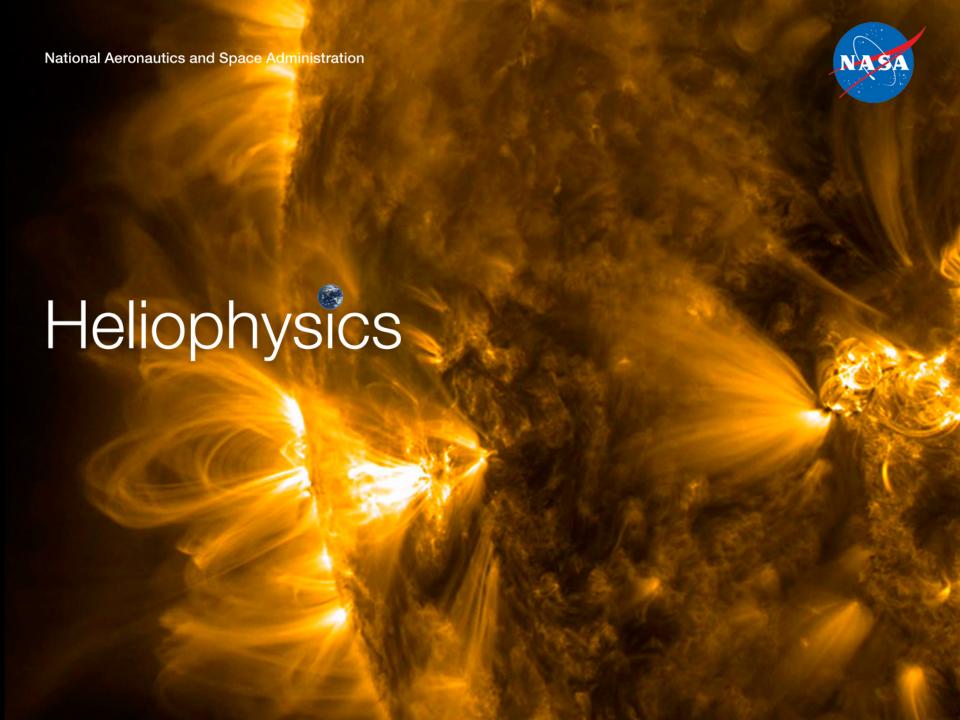


#### **Outline**

Science Results

#### Programmatic Status

- Heliophysics
- Earth Science
- Planetary Science
- Astrophysics/JWST
- Findings & Recommendations



### FY14 Program Accomplishments

- ◆ BARREL: Balloon campaign #2, Antarctica, in December 2013/January 2014
  - MMS: Complete observatory integration and testing
    - Successful Pre-ship Review and Operational Readiness Reviews
    - Ship to launch site for successful launch in March 2015
  - SPP: Retire technology development risks, transition formulation to development.
    - ✓ Successful mission PDR in January 2014
    - –√KDP-C Confirmation Review in March 2014
  - SOC: SoloHI and HIS instrument Critical Design Reviews
    - Launch vehicle procurement and contact awarded
- ✓ GOLD: Successful System Requirements Review in January 2014
  - Preliminary Design Review in October 2014
- ✓ ICON: Successful System Requirements Review in January 2013,
  - ✓ PDR in July 2014,
    - Confirmation Review Upcoming (TBD)
  - R&A: Enable compelling science addressing key problems in heliophysics

## **STEREO High Gain Antenna tests**

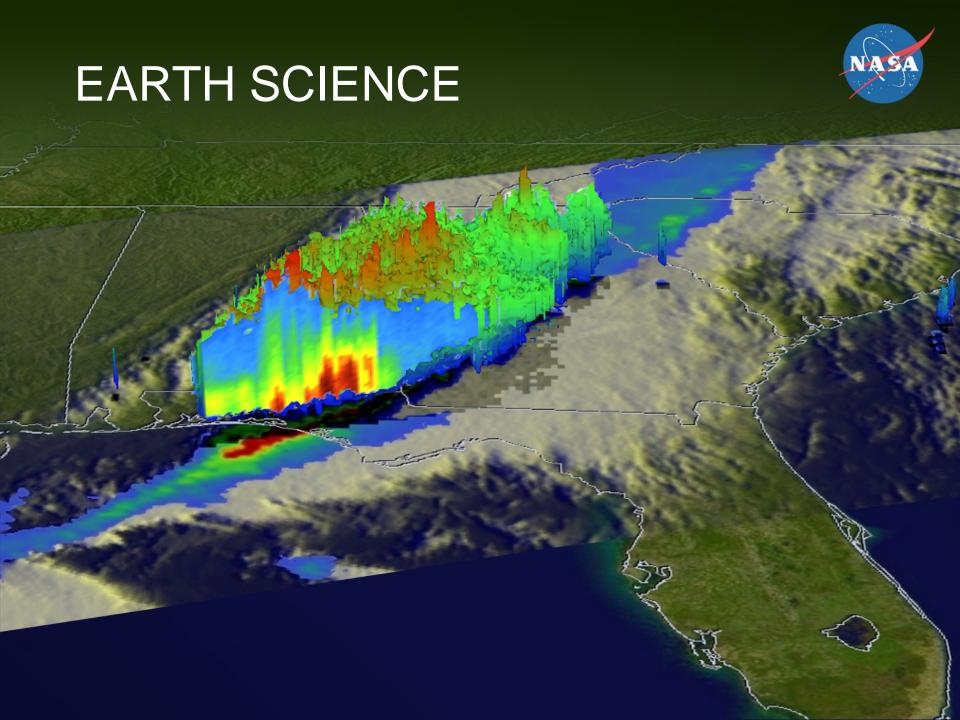
#### **Description of the problem:**

On 7/6 in preparation the solar conjunction configuration tests on the AHEAD observatory were conducted. The PLASTIC and IMPACT instrument suites ramped down the necessary high voltages and the SECCHI COR1 and 2 covers were closed. A flight software patch was loaded to the IMPACT IDPU in preparations for the reduced data rates on HGA side lobes. The remaining science data on the SSR was played back. The necessary S/C bus telemetry configurations for side lobe operations were loaded to C&DH RAM and verified consisting of MOps macro release 1.1.22. In accordance with the solar conjunction entry procedure, a final snapshot of the analog diagnostic data in the data summary table was dumped. The PLASTIC and IMPACT instrument suites were powered down at 1830z, the SECCHI instrument at 1835z, and the SWAVES instrument at 1840z. Reduced gyro operations are continuing and G&C control gains were adjusted for lack of SECCHI GT input.

On 7/9 surprisingly good RF performance was demonstrated with telemetry in lock for 5 minutes per rotation and carrier lock for more than half of the rotation. The rate was 633 bps.

On 7/14, all the instruments had been restored to pretest configurations without incident.

This bodes well for the superior conjunction configuration in August.





## OCO-2 Delta II Launch - July 2, 2014

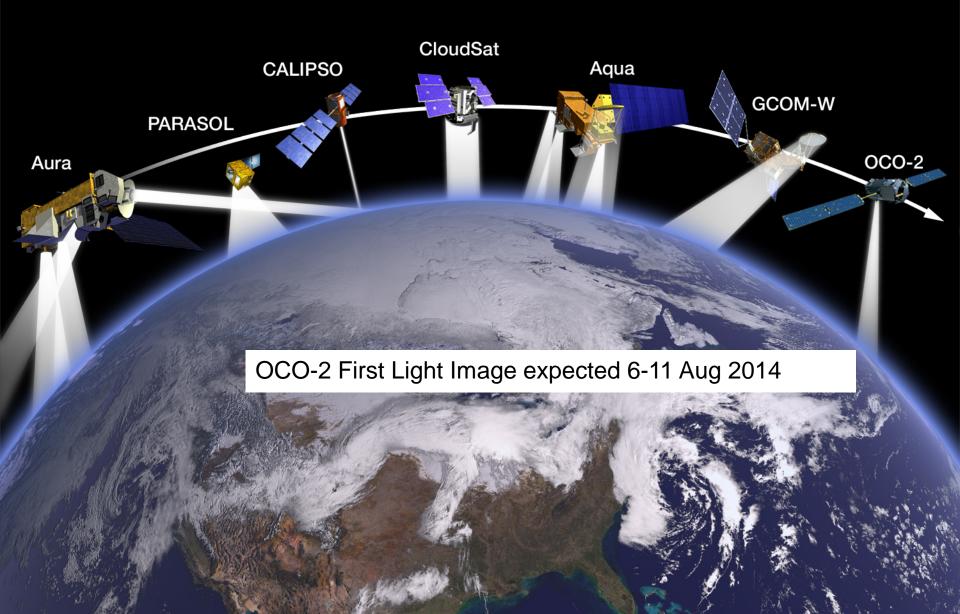


Lift-Off from SLC-2W (Space Launch Complex 2 West), Vandenberg Air Force Base (VAFB), CA, 2:56:23.272 am PDT, Tuesday, July 2, 2014



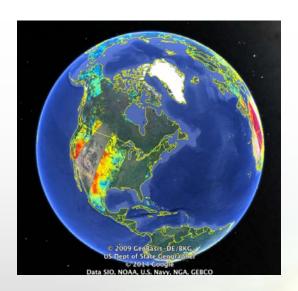
Five Minute-Long Exposure Image of the OCO-2 Delta II Launch from Santa Cruz, CA, Approximately 200 Miles from VAFB

## A-Train



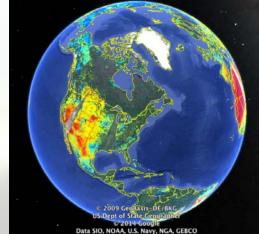


#### **SMAP Soil Moisture Products**



SMAP will provide moisture content measurement in the top 5 cm of soil at 10 km resolution globally every 3 days

Days 1+2

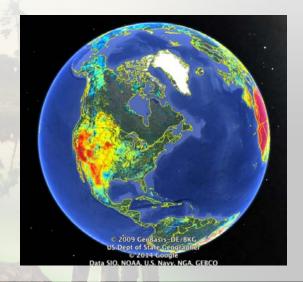


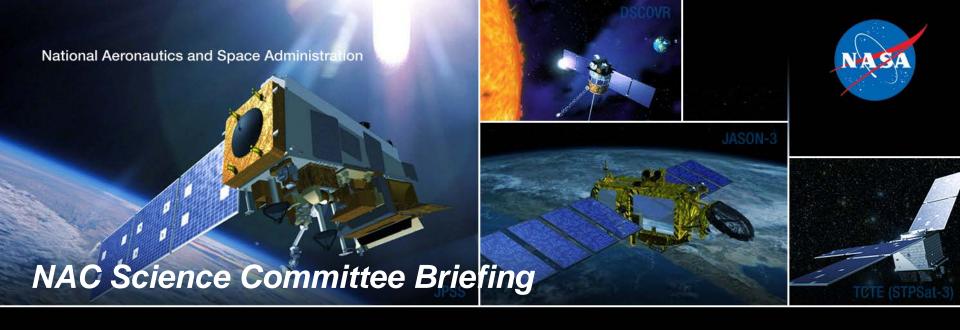
SMAP measurements of soil moisture address a wide range of water cycle research and science applications, such as weather predictions, drought/flood monitoring, and food production.

The illustrations provide the soil moisture color-coded with orange for dry conditions and blue for wet conditions.

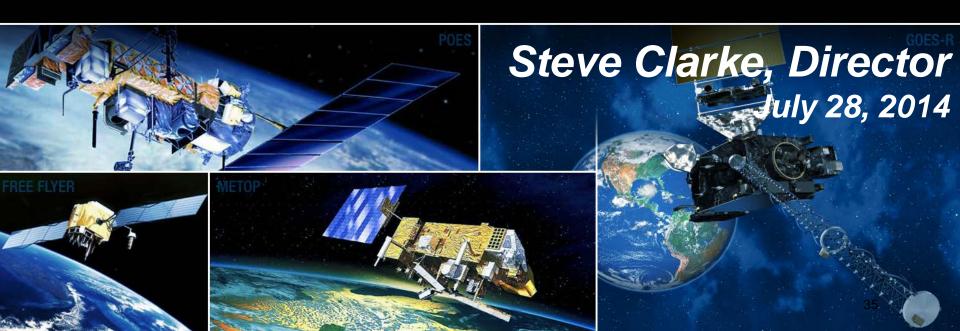


Days 1-3





## Joint Agency Satellite Division





#### **JASD Summary**

#### JPSS

- JPSS-1 spacecraft build, instrument testing, and ground segment continues to make good progress toward a 2Q FY2017 launch date.
- JPSS-2 spacecraft RFO release scheduled for August and award in April 2015. Instrument negotiations are either complete or near completion.
- Continue working Polar Follow On (JPSS-3 and 4) formulation options to ensure JPSS Robustness

#### GOES-R

 GOES-R spacecraft, instruments and ground segment working through challenges with sufficient margin to meet the 2Q FY2016 launch date.

#### DSCOVR

- The DSCOVR spacecraft activities are nearly complete and continue to support shipment to the launch site (CCAFS) in November for a January 13, 2015 launch date.
- Launch vehicle interface details continue to be worked between the spacecraft project and SpaceX.

#### Jason-3

- The Jason-3 spacecraft is proceeding nominally through its environmental test campaign.
- Continuing to work launch vehicle readiness and FY15 funding availability to support a March 31, 2015 launch date.

#### MetOp-C/POES

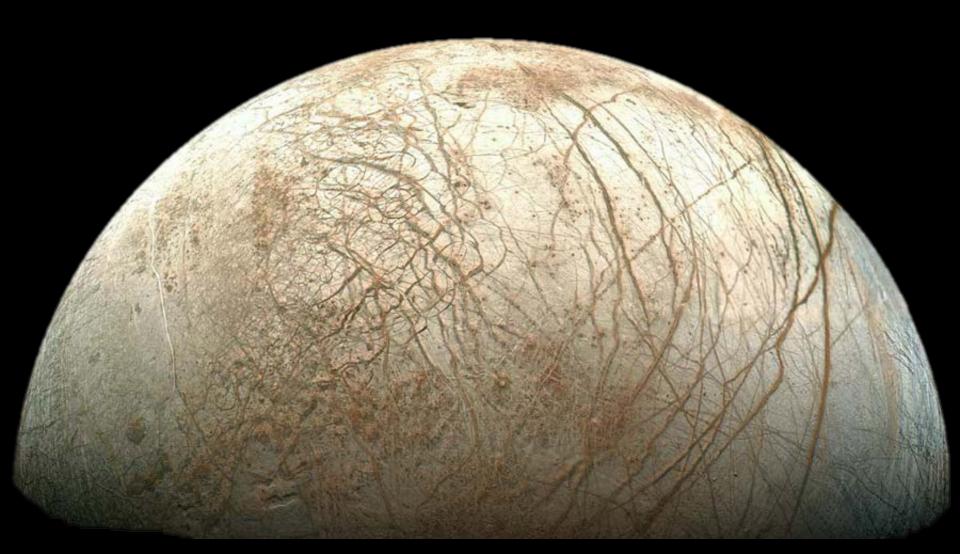
MetOp-C Instruments continue to perform well after recent activation and re-calibration activities

#### Solar Irradiance, Data and Rescue (SIDAR)

- Planning continues with the ISS Program to accommodate the TSIS-1
- Continuing to look for rideshare opportunities for A-DCS and SARSAT



# Planetary Science



## **Planetary Science Missions Events**

as of July 24, 2014

**Completed** 

#### 2014

July – Mars2020 Rover instrument selection announcement

Fall - Curiosity arrives at Mt. Sharp

September 21 - MAVEN inserted in Mars orbit

October 19 – Comet Siding Spring encounters Mars

November 11 - ESA's Rosetta mission lands on Comet Churyumov-

Gerasimenko

Nov/Dec – Launch of Hayabusa-2 to asteroid 1999 JU<sub>3</sub>

#### 2015

March - MESSENGER spacecraft impacts Mercury

Late March – Dawn inserted into orbit at dwarf planet Ceres

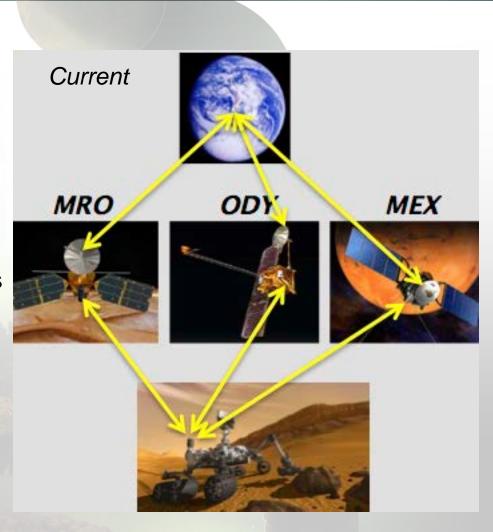
April - Europa instrument Step 1 selection

May - Discovery 2014 Step 1 selection

July 14 – New Horizons flies through the Pluto system

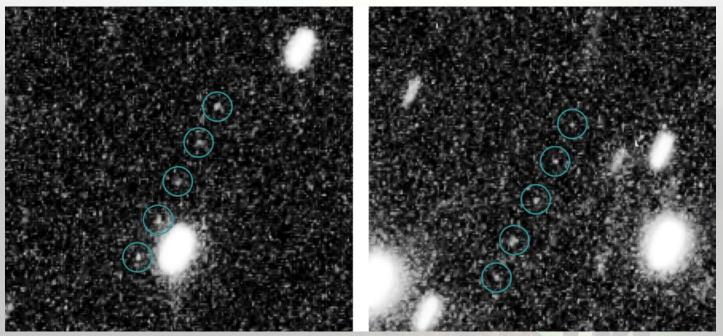
# Mars Commercial Telecomm RFI

- Seeking business models for datarelay services
  - Orbiter to surface or orbiter-toorbiter
- Also options to upgrade service at Mars starting in the 2020s
  - Optical com & other ideas
- For planning purposes only understanding the range of options
  - What is possible and what makes sense to potential providers
  - Range of possible costs and implementation models
- Ten pages, due August 25<sup>th</sup>
   http://go.nasa.gov/1kV6KYj



# Hubble Space Telescope

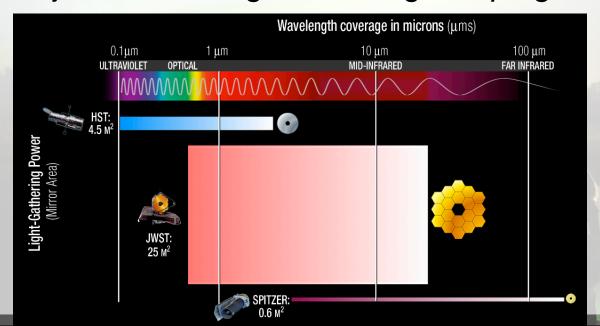
- Hubble conducting search for Kuiper Belt Object suitable as New Horizons flyby destination following Pluto flyby
- 154 orbit observing program recommended by TAC conditional on successful 40 orbit pilot program to validate predicted source counts and expected probability of success
- June 2014 pilot successful; at least two KBOs detected
- Full search underway through August 2014



These two multiple-exposure images from NASA's Hubble Space Telescope show Kuiper Belt objects, or KROs

# **Astrophysics Division Telescopes**

- HST surveys approved:
  - Looking for a NH KBO & Europa plumes
- Spitzer operations extended for the next two years
  - Astrophysics and the Planetary Science Divisions have requested observing time commitments for FY15
- Spitzer & Keck solicit high priority investigations of solar system objects, <u>including monitoring campaigns</u>





#### WFIRST / AFTA

Widefield Infrared Survey Telescope with Astrophysics Focused Telescope Assets

- FY14 appropriation supports pre-formulation of WFIRST/AFTA, including technology development for detectors and coronagraph (joint with STMD).
- FY15 request supports Agency/Administration decision for formulation to begin NET FY 2017, should funding be available.



Recent (March 2014) NRC study on WFIRST/AFTA offers positive view of science impact of WFIRST/AFTA with cautions about technology and cost risks. Risk reduction investments are being made that address these concerns.



#### SOFIA

#### Stratospheric Observatory for Infrared Astronomy



- World's Largest Airborne Observatory
- 2.5-meter telescope
- Capable of observing from the visible to the far infrared
- 80/20 Partnership between NASA and the German Aerospace Center (DLR)
- Mission Ops based at NASA-Armstrong
- Science Ops based at NASA-Ames
- Six First-Generation instruments
  - Four U.S., two German
  - Imaging, Spectroscopy, and Photometry
- Limited Science Ops began in 2010
- Full Operational Capability in February 2014

#### **CURRENT STATUS:**

- Achieved Full Operational Capability Feb 2014.
- Began Cycle 2 Science Observations Feb 2014.
- Completed commissioning flights for Field-Imaging Far-Infrared Line Spectrometer (FIFI-LS) April 2014 (5<sup>th</sup> instrument).
- Initiated commissioning of Echelon-Cross-Echelle Spectrograph (EXES) April 2014 (6<sup>th</sup> instrument).
- Demonstrated high cadence science operations in April/May 2014.
- Formally entered Operational Phase May 2014.
- Second generation instruments under development.
  - HAWC+: far infrared imager and polarimeter.
  - upGREAT: multi-pixel heterodyne spectrometer.
- IG report issued July 2014.
- Arrived in Germany on June 28, 2014 for Heavy Maintenance Visit.
- President's FY15 budget request proposes to end funding and place SOFIA in storage.
  - NASA/DLR Working Group analyzed several scenarios to establish SOFIA's path forward.
  - Currently executing SOFIA's baseline schedule of operations and scheduled maintenance for FY14.
  - House proposed \$70M for FY15 operations.
  - Senate proposed \$87M for FY15 operations.



# **Astrophysics 2014 Senior Review**

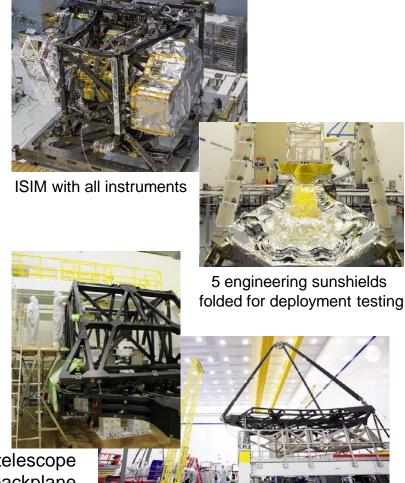
- Hubble Space Telescope: extension approved
- Chandra X-ray Observatory: extension approved
- Swift Gamma-ray Burst Explorer: extension approved
- Nuclear Spectroscopic Telescope Array (NuSTAR): extension approved and new GO program
- X-ray Multi-Mirror Mission-Newton (XMM-Newton) (ESA mission): extension approved and augmented GO program
- Fermi Gamma-ray Space telescope: extension approved
- Kepler Space Telescope: K2 extension approved
- Spitzer Space Telescope: mission extended after original decision
  - SMD determined that Spitzer infrared observations are an important resources for research programs across SMD. Both Astrophysics and Planetary Science Divisions identified observing time requirements for FY15 and both Divisions have committed funding to support their observations
- Suzaku (JAXA mission): extension approved; no GO augmentation
- Planck (ESA mission): reduced augmentation approved
- Widefield Infrared Survey Explorer (NEOWISE-R): data analysis proposal not approved

http://science.nasa.gov/astrophysics/2014-senior-review-operating-missions/



# **JWST** Progress

- All science instruments installed into ISIM for cryo-vacuum testing this month
- First two of 5 flight sunshields being manufactured, 5 engineering sunshields being used for deployment testing
- Spacecraft bus under construction
- Good progress continues on telescope flight backplane testing and backplane pathfinder
- Program remains on track for October 2018 launch and within budget.

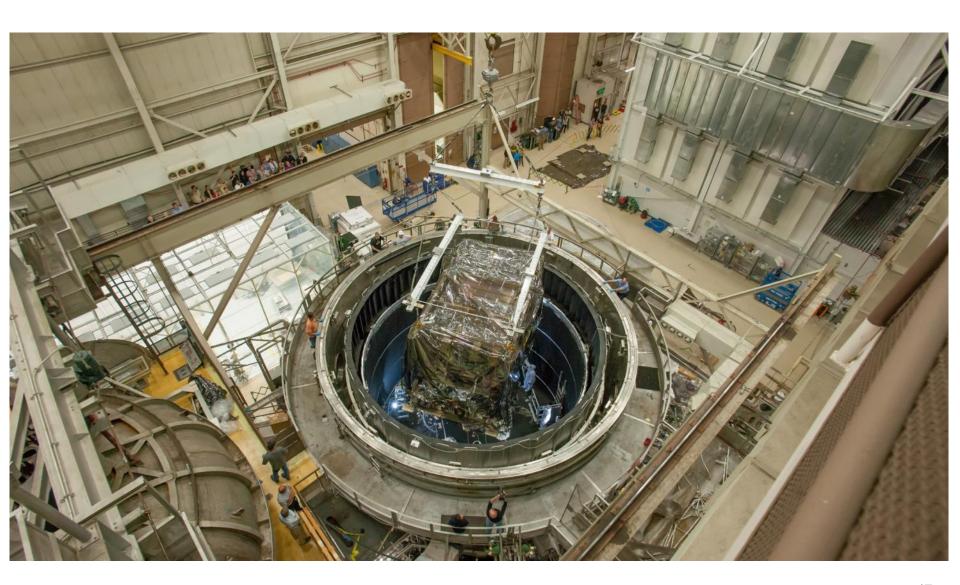


Flight telescope backplane & backplane support fixture

Pathfinder (backplane center section with secondary mirror structure)

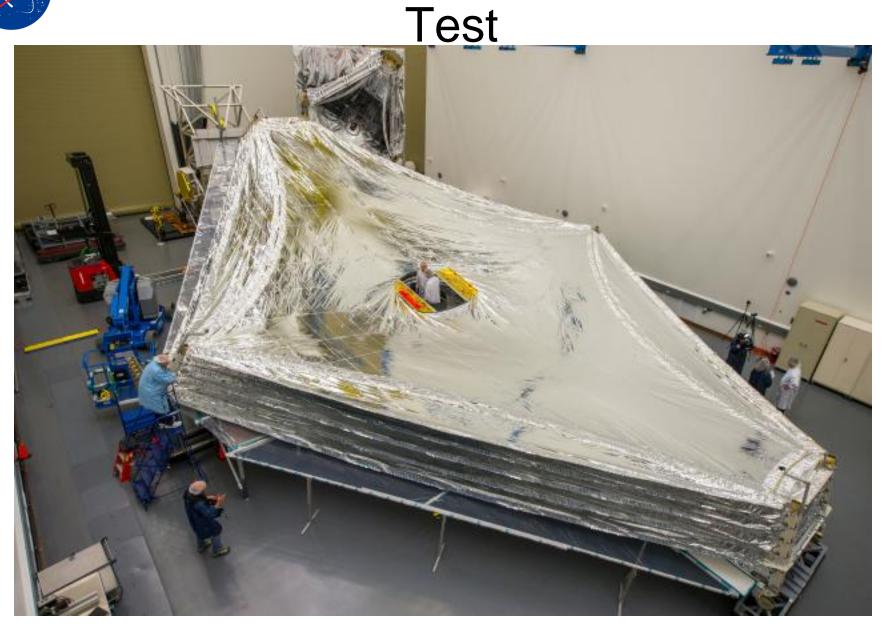


# Integrated Science Instrument Module → the SES Chamber



NASA

Engineering Sunshield Deployment



# **Outline**

- Science Results
- Programmatic Status
- Findings & Recommendations

# TI&E and Science Committees Recommendation

#### **Recommendation:**

The Council recommends that the STMD AA & SMD AA engage with each other and their communities to determine how policies and procedures could be modified to allow the infusion of new mission-enabling and mission-enhancing technologies developed by Principal Investigators, STMD or others in small to medium class missions.

#### **Major Reasons for the Recommendation:**

- In highly competitive program solicitations, such as Discovery and Explorer, there is a disincentive to propose new technology because of the perceived risk.
- As a result, NASA may be missing an opportunity to leverage scientifically beneficial technology through small and medium science missions. In the longterm, this could erode NASA's scientific and technical capabilities.
- If the Agency wants to encourage and infuse appropriate new technologies in its small and medium class missions, it must develop a policy that provides a pathway to the inclusion of these technologies in the solicitation release.

#### **Consequences of No Action on the Recommendation:**

Erosion of NASA's science and technical capabilities

# Finding → SMD AA

### **JWST Funding Wedge**

The Science Committee encourages the SMD AA to review the history and evolution of the JWST funding wedge within SMD. The Science Committee believes it would be valuable for SMD to assess the relative contributions toward JWST from all of its divisions and their impacts in developing a Directorate-wide science strategy that optimizes post-JWST SMD science within the available resources, taking into account the relevant decadal surveys and a balanced portfolio.

# Finding → SMD AA

#### **SMD Education and Communications**

The Science Committee commends SMD for the establishment of the new Education and Communications group within the SMD front office. The Science Committee continues to stress the absolute criticality of such activities as part of the ongoing work of Earth and space sciences at NASA. We look forward to tracking progress in this area, and in particular, learning how the program maintains a diversity of size of education and communications programs and how they couple with mission scientists, engineers and others.